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MANUFACTURE OF CEMENT

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Cement is one of the most adaptable and well known materials of today. It is used in modern building construction, bridges, dams, roads and many other things. The trend in the building industry is toward fireproof structures, and in this cement plays an important part. Fire losses are cut down tremendously by its use. The annual output of the cement plants in this country totals 164 million barrels.

There are three kinds of cement: natural, slag, and portland. The last, the best known and most widely used, is named portland due to its resemblance to portland stone, which is very common in England and Wales.

Cement plants are usually located near the source of water, power supply and raw materials. The plant must be located near the raw materials which are used in its manufacture, such as limestone, shale and gypsum; for proximity to supply determines how cheaply the product can be manufactured.

There are two different processes in the manufacture of cement, the wet and the dry. Since these are so much alike, it is only necessary to give the wet process.

The limestone quarry is located near the plant, usually not more than a mile away. The limestone is loosened by blasting. Blasting material is placed in holes drilled back of the face of the quarry, and set off. The broken limestone is carried away by Koppel (dump) cars to the crushing plant.

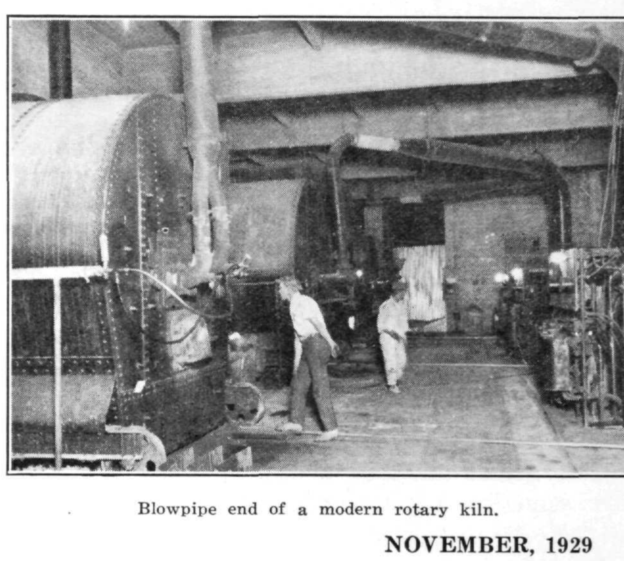
The limestone as it comes from the quarries cannot be used directly, but must be crushed into convenient size (egg). The crushing is done by huge rimless spoked wheels flying around in opposite directions. The wheels, twelve in number, are about 8 feet in diameter and have a width of about 5 feet. The broken rock as brought from the quarry is dumped into steel-lined concrete hoppers conveyed by endless belts into the crusher. To keep the rock from flying about and to protect the workmen, a hood is built over the crushers. These crushers, of which there are two, are also used for crushing of shale. Either one or the other or both materials can be crushed at the same time. The crushed product is sent by conveyors to the bins above the raw mills or to general storage.

The raw grinding department consists of several rotary mills. These mills are approximately 28 feet and have two diameters 8 feet at the feed end and 6 feet in diameter for the rest of the tube. The raw mills are fed by table-type feeders set at an incline to discharge into an inlet chute to the mill and permit unusually close regulation of the feed. Into these feeders are fed limestone, shale and water in the proportion of about 464 lbs., 116 lbs., and 327 lbs., respectively.

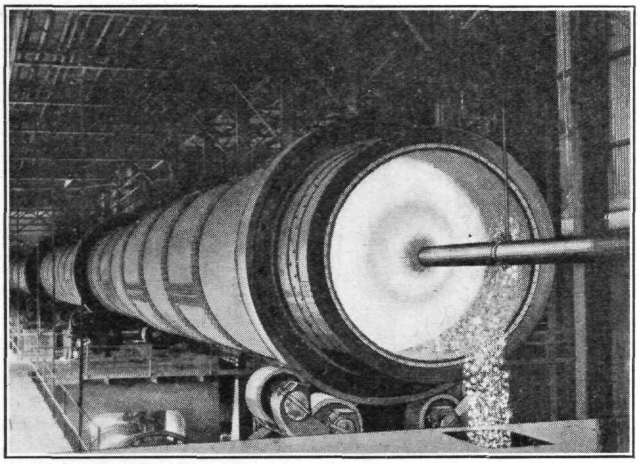
These rotary mills are horizontal steel cylinders revolving at the rate of 23 to 25 revolutions per minute on its horizontal axis. Curved steel plates arranged in steps form the lining of the drum, which is partly filled with steel balls or slugs. As the cylinder rotates, these balls are carried up the side only to be thrown toward the center and down against the material in the bottom of the cylinder. These hammerlike blows break the mixture of limestone and shale into a powder. This powder goes to a tube mill somewhat similar to the raw mill. The tube mill contains flint pebbles instead of steel balls. This mill accomplishes the final grinding of the raw material, producing a powder so fine that 85 per cent will pass a sieve that holds water.

After leaving the raw mills, the product is a soupy mixture, called slurry. The slurry is pumped by air-lift pumps to the slurry storage and blending tanks. There are fifteen of these slurry tanks, five of which are used for blending purposes only. The tanks are 23 feet in diameter and 37 feet deep. To keep the slurry constantly mixed, air is forced up through the slurry at three-minute intervals. The valves that release the air are in the bottom of the tank and connected by cams giving accurate and efficient agitation.

Calcination is done by burning the slurry in large inclined rotary kilns. These kilns are 11 feet 6 inches in diameter, 175 feet long and are inclined from ½ inch to ¾ inch per foot. The kiln is revolved at the rate of ¾ turn per minute. Powdered coal is used for fuel and produces a temperature of 2500 to 3000 degrees Fahrenheit, a temperature far above the melting point of steel. The coal is blown into the lower end of the kiln, producing a flame 30 to 40 feet in length. The slurry after proper blending is introduced into the rotary kiln at the upper end. Under the influence of the intense heat the intimately associated particles react chemically to form a new compound and emerge from the end of the kiln as white-hot clinker. The clinker is glass hard and about the size of marbles. The clinker after having cooled is an inert material and can be stored to build up a reserve for the busy seasons. This clinker is stored in clinker tanks, but in case excessive quantities are on hand it is placed in general storage. When the clinker is taken from storage for final grinding a small amount of gypsum —not to exceed 3 per cent by weight—is added to



Blowpipe end of a modern rotary kiln.



Blowpipe end of large rotary kiln with hood removed, showing clinkers dropping into coolers below.

control the rate of hardening when cement is used.

The grinding of the clinker is practically the same as that of raw materials. After the first grinding it is about the size of sand grains. The final grinding produces a powder that is finer than flour and at least 78 per cent must pass a sieve having 40,000 openings per square inch. This powder is the finished product—cement. The cement is now ready for packing, either in sacks or barrels. The cement is usually stored in large storage tanks of which there are about ten in number. These tanks or silos are 80 feet high and have a combined capacity of about 250,000 barrels. The cement is pumped to these silos, the pumping arrangement allowing a by-pass direct to the packing bins, where sacks and barrels may be filled directly if desired.

Great care is taken in the proper burning or calcination of the limestone (calcium carbonate). It must be entirely changed by the burning process into calcium oxide. This takes about two hours to accomplish. The raw materials have their first test while yet in the ground to determine their essential ingredients. This test provides a guide in mixing the materials at the plant. After grinding, but before burning, the "raw mix" is the subject of further tests to check its proportion. Any adjustment necessary is made by proper blending of the slurry before it enters the kiln.

At every important stage of the manufacturing automatic devices take up samples for testing every hour. In making chemical analyses, quantities are determined to one ten-thousandth of a gram. Finally when the burned material has been pulverized to finished cement, it is subjected to eleven further chemical and physical tests, all made at frequent intervals. The important ones are repeated on samples taken just before the car is shipped.

The final tests are (1) for fineness, (2) for strength, (3) for soundness, (4) for setting time, (5) for freedom from impurities. These qualifications are all covered by the exacting specifications of the American Society of Testing Materials and the United States Government.

A handful of the finished product taken at random—any handful of the more than 32 million tons of cement produced annually — must meet these specifications at every point before the cement goes to the user. Hence, several trained specialists are constantly engaged in testing at the various stages of manufacture of cement.

The modern plant is usually operated by its own power plant. Power is generated by waste-heat boilers. The hot gases, leaving the kilns during the course of manufacture, are used as a means for supplying heat to these boilers. The boilers are equipped with powdered coal burners so that these can be used as auxiliary units in case of necessity. Steam is generated at about 225 pounds pressure at a 150 degree superheat. The electricity is generated by turbine generators.

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AUTHOR'S NOTE

The material for this article was gathered on an inspection tour through the Osborn, Ohio, plant of the Southwestern Portland Cement Company. Mr. W. J. Jennings, assistant general manager of the plant, gave me permission to go through the plant and furnished much valuable information.